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RESUMO/ABSTRACT

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Keywords: outsourcing, capital structure, incentives, uncertainty
JEL classification: D81; G32; G33; L23; L24

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Abstract

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1 Introduction

This paper extends the work by Teixeira (2011) by investigating the role of debt on a firm's decision to outsource. We show that as the surplus from outsourcing gets larger, such that it is enough to cover the supplier's limited liability rent, there is scope for the supplier to issue debt, rather than accumulate cash. Debt has the opposite effect of cash on the supplier's value, and the supplier has the incentive to issue as much debt as possible, provided that the buyer still chooses the outsourcing regime. Additionally, we find that the supplier's debt is always risky as its limited liability results in a compensation scheme where there are only positive transfer payments in the good state of nature. In the bad state of nature the limited liability constraint binds, and as a consequence the outsourcing transfer payment is zero. Since the supplier's debt is risky, it is associated with bankruptcy costs. Our results show that the supplier's decision of issuing debt represents a trade-off between increased bargaining power in collecting the outsourcing surplus and higher bankruptcy costs, and that the total firm value is maximized for maximum debt.

Furthermore, we find that the supplier's equilibrium reaction with debt depends on whether the buyer is outsourcing with safe or risky debt, as outsourcing with risky debt involves bankruptcy costs that do not arise with safe debt. If the buyer's debt is safe, what determines the use of debt by the supplier is only the balance between the surplus from outsourcing and the supplier's limited liability rent. If, however, the buyer's debt is risky, there is a value loss in the buyer's total firm value due to bankruptcy costs, and as a consequence the supplier's decision of issuing debt has to take into account these additional costs.

We also examine how the level of priority of the firms' creditors over the value of production in bad states of nature affects the total firm value of each firm under

outsourcing. We consider that, in addition to the transfer payments of the outsourcing contract, the payoff to the firms' creditors depends on a priority rule over the value of production that remains to be transferred at liquidation. We find that each firm's creditors benefit from a higher level of priority over the value of production in bad states of nature.

Finally, we find that the buyer's decision to outsource with safe or risky debt also depends on the magnitude of the surplus from the outsourcing contract, in particular on how this surplus compares with the value of production in the bad state of nature. Our model predicts that outsourcing with risky debt is more likely to occur when there is a greater advantage from outsourcing. Moreover, we show that the level of priority of the firm's creditors over the value of production also plays a role in the equilibrium capital structure: a higher level of priority of the buyer's creditors over this value favors an equilibrium where the buyer's debt is safe.

Before proceeding, we further contrast our analysis of the principal-agent model of outsourcing with related work in the literature.[1] As in Sappington (1983), Lewis and Sappington (2000) and Laffont and Martimort (2002), we derive a contract with limited liability constraints, and show how these constraints create a limited liability rent that accrues to the agent. More recently, Grossman and Helpman (2004) take an incentive scheme approach to explore the production decision in a model with limited liability constraints. They focus on the trade-off between greater monitoring under vertical integration and high-powered incentives for effort under outsourcing. We extend this literature by examining the link between the firms' capital structure and the production decision. Moreover, contrary to Grossman and Helpman (2004), we focus on costs differential as the main motivation for firms to outsource.

There is both empirical and anecdotal evidence that firms outsource to take ad-

[1]Bolton and Dewatripont (2005), Laffont and Martimort (2002), Salanie (1999) and Hart (1995) provide extensive analysis of the main models on the theory of incentives.

vantage of cost differentials. Fixler and Siegel (1999) show that the propensity of a firm to outsource is a function of the difference between the price or marginal cost of the product or service and the marginal cost of in house production. Among the determinants for these cost differentials are differences in wages, the use of superior technology, economies of scale, or monitoring and transaction cost savings. Domberger (1999) and Greaver (1999) refer the existence of anecdotal evidence where one of the main reasons for outsourcing is "functional specialization", allowing the supplier to produce at a lower cost. Theoretical models that examine the choice between outsourcing and vertical integration have also incorporated cost differentials as a motive for outsourcing. The main contributions in this field include Grossman and Helpman (2002), McLaren (2000) and Antras and Helpman (2004) in the incomplete contracting or transaction economics literature, and Buehler and Haucap (2006), Chen (2001) and Shy and Stenbacka (2003) in the literature that has highlighted the role of strategic competition for a firm's decision to outsource.

The remainder of the paper is organized as follows. Section 2 examines the equilibrium when debt is issued. Section 3 concludes. Proofs of all propositions are given in the Appendix.

2 The model with debt

In this section we assume that the surplus from the outsourcing regime is greater than the limited liability rent captured by the supplier, such that the supplier can use debt as an instrument to collect this surplus, i.e. $\frac{\pi_0}{\Delta\pi}\psi_S \leq M - \psi_S$. We follow closely the structure of the previous setting with cash, considering now the relevant adjustments to the model implied by the introduction of debt on each firms' capital structure. We start off with the assumption that both firms' debt is exogenously given and subsequently derive the equilibrium capital structure under outsourcing.

Let us then specify some of the new features of the model with debt in order to determine the equilibrium with exogenous debt. At time $t = 0$ the buyer and the supplier have in their capital structure a pure discount debt with face values of D_B and D_S, respectively. Analogously as before, at this time the buyer offers a contract $\left(\overline{t}, \underline{t}\right)$ and at time $t = 1$ the supplier accepts or refuses the contract. In case of acceptance, at time $t = 2$ the supplier exerts effort or not. Then, at time $t = 3$ the stochastic value of production $\widetilde{S}$ is realized and at time $t = 4$ the contract is executed and the face values of debt D_B and D_S are paid.

The introduction of debt, particularly in the supplying side, creates an important difference between this framework and the one with cash holdings, when we end up in the bad state of nature. While in the model with cash holdings the realization of $\underline{S}$ is fully captured by the buyer, here we assume that the creditors of the supplying firm can claim some of this value of production. This may occur when the transfer payment $\underline{t}$ received by the supplier is not enough to pay the face value of debt D_S to the creditors ($\underline{t} - D_S < 0$), i.e. when the supplier's debt is risky. In that case, we assume the existence of a priority rule over $\underline{S}$, where the creditors of the supplying firm receive a fraction $\alpha \in [0, 1]$ of the realized value of production (up to the maximum that is the face value of debt D_S) and the buyer receives $(1 - \alpha)$.[2] If $\alpha = 0$ the buyer has strict priority over $\underline{S}$, whereas if $\alpha = 1$ it is the creditors of the supplying firm who have strict priority over $\underline{S}$. When $\underline{S}$ is realized, two cases can arise: either the realized value of production is higher than the supplier's face value of debt, $\underline{S} \geq D_S$, or it is lower, $\underline{S} < D_S$. Therefore, in what follows we define the payoffs to the firms' creditors for each of these cases.

Furthermore, whenever the buyer's or the supplier's debt is risky, we assume the existence of bankruptcy costs that are captured by a parameter $\delta_i \in [0, 1]$ with i

[2]Without loss of generality, we assume that the outsourcing contract specifies *ex-ante* through this absolute priority rule how the value of production is shared between the supplier's creditors and the buyer, when $\underline{S}$ is realized. In bankruptcy it is assumed that this rule is legally binding.

$\in \{B, S\}$ and where B stands for buyer and S for supplier. If $\delta_i = 0$ we are in the extreme case of no bankruptcy costs.

Under these assumptions, it follows that if $\underline{S} \geq D_S$, the payoffs to the creditors of the buyer and the supplier are, respectively: $\min\left[D_B, (\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha)\,(1 - \delta_B)\right]$ and $\left[\min\left[D_S, \underline{t}\right] + \max\left[D_S - \underline{t}, 0\right]\alpha\,(1 - \delta_S)\right]$. If, however, $\underline{S} < D_S$, the payoffs are, respectively: $\min\left[D_B, (1 - \alpha)\,(\underline{S} - \underline{t})\,(1 - \delta_B)\right]$ and $\min\left[D_S, \underline{t} + (\underline{S} - \underline{t})\,\alpha\,(1 - \delta_S)\right]$.

Now, we are in a position to specify the value functions of each claimant participating in the outsourcing regime. Consider first the supplier. The values of equityholders' and debtholders' claims are $SEquity^{O}_{e=1}$ and $SDebt^{O}_{e=1}$. The claims add up to the total firm value, $S^{O}_{e=1} = SEquity^{O}_{e=1} + SDebt^{O}_{e=1}$. It follows that the equity value is given by:

$$SEquity^{O}_{e=1} = \pi_1 \max\left[\overline{t} - D_S, 0\right] + (1 - \pi_1)\max\left[\underline{t} - D_S, 0\right] - \psi_S \tag{1}$$

whereas the debt values for $\underline{S} \geq D_S$ and $\underline{S} < D_S$ are, respectively:

$$SDebt^{O}_{e=1} = \pi_1 \min\left[D_S, \overline{t}\right] + (1 - \pi_1)\left[\min\left[D_S, \underline{t}\right] + \max\left[D_S - \underline{t}, 0\right]\alpha\,(1 - \delta_S)\right] \tag{2}$$

$$SDebt^{O}_{e=1} = \pi_1 \min\left[D_S, \overline{t}\right] + (1 - \pi_1)\min\left[D_S, \underline{t} + (\underline{S} - \underline{t})\,\alpha\,(1 - \delta_S)\right] \tag{3}$$

As regards the buyer, the value functions of equity, $BEquity^{O}_{e=1}$, and debt, $BDebt^{O}_{e=1}$, for $S \geq D_S$ are given by:

$$BEquity^{O}_{e=1} = \pi_1 \max\left(\overline{S} - \overline{t} - D_B, 0\right) + (1 - \pi_1)\max\left(\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha - D_B, 0\right) \tag{4}$$

$$BDebt^{O}_{e=1} = \pi_1 \min\left[D_B, \overline{S} - \overline{t}\right] + (1 - \pi_1)\min\left[D_B, (\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha)\,(1 - \delta_B)\right] \tag{5}$$

and for $\underline{S} < D_S$ these are defined as:

$$BEquity^{O}_{e=1} = \pi_1 \max\left(\overline{S} - \overline{t} - D_B, 0\right) + (1 - \pi_1)\max\left((1 - \alpha)\,(\underline{S} - \underline{t}) - D_B, 0\right) \tag{6}$$

$$BDebt^{O}_{e=1} = \pi_1 \min\left[D_B, \overline{S} - \overline{t}\right] + (1-\pi_1)\min\left[D_B, (1-\alpha)\left(\underline{S} - \underline{t}\right)(1-\delta_B)\right] \quad (7)$$

The buyer optimizes the firm value, $B^{O}_{e=1} = BEquity^{O}_{e=1} + BDebt^{O}_{e=1}$, selecting the contract $\left(\overline{t}, \underline{t}\right)$ that satisfies the supplier's incentive, participation and limited liability constraints. The supplier's incentive constraint, $SEquity^{O}_{e=1} \geq SEquity^{O}_{e=0}$, now simplifies to:

$$\begin{aligned} & \pi_1 \max\left[\overline{t} - D_S, 0\right] + (1-\pi_1)\max\left[\underline{t} - D_S, 0\right] - \psi_S \\ \geq \; & \pi_0 \max\left[\overline{t} - D_S, 0\right] + (1-\pi_0)\max\left[\underline{t} - D_S, 0\right] \end{aligned} \quad (8)$$

The participation constraint, $SEquity^{O}_{e=1} \geq 0$, is given by:

$$\pi_1 \max\left[\overline{t} - D_S, 0\right] + (1-\pi_1)\max\left[\underline{t} - D_S, 0\right] - \psi_S \geq 0 \quad (9)$$

Finally, the supplier's limited liability constraints are:

$$\overline{t} \geq 0 \quad (10)$$

$$\underline{t} \geq 0 \quad (11)$$

Using similar techniques as before, one can show that the optimal compensation scheme that solves the buyer's problem is the one that considers as binding both the incentive and the limited liability constraints (8) and (11), respectively. Proposition 1 summarizes the equilibrium transfer payments with exogenous debt.

Proposition 1 *Assume that prior to the acceptance of the outsourcing contract by the supplier, the buyer and the supplier hold and exogenous debt level D_B and D_S, respectively. The equilibrium transfer payments of the outsourcing contract are:*

$$\overline{t}^{*} = \frac{1}{\Delta\pi}\psi_S + D_S \quad (12)$$

$$\underline{t}^{*} = 0 \quad (13)$$

While in the bad state of nature there is no reward to the supplier through the compensation scheme, there is a reward in the good state that incorporates the debt payment that has to be made to the supplier's creditors. Moreover, since the supplier's transfer payment in the bad state of nature is zero, it follows that the firm's debt is always risky.

In order to derive the equilibrium value functions for an exogenous amount of each firms' debt, we need to substitute the equilibrium transfer payments into the value functions above. Furthermore, we have to define under which conditions the buyer's debt is safe or risky as risky debt is associated with bankruptcy costs that do not arise with safe debt. From the buyer's equity value function we know that the buyer's debt is safe if $\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha \geq D_B$ and risky if otherwise. As in equilibrium $\underline{t}^* = 0$ (see proposition 1), the conditions for the buyer's safe and risky debt simplify to $\underline{S} - \alpha D_S \geq D_B$ and $\underline{S} - \alpha D_S < D_B$, respectively.

Propositions 2 and 3 summarize the equilibrium with exogenous debt when the buyer's debt is safe and risky, respectively. With the results of proposition 2 alone we can discuss the effect of the supplier's debt on the buyer's outsourcing decision, whereas with the results of proposition 3 we can analyze the additional effect of the buyer's bankruptcy costs.

Proposition 2 *Assume that prior to the acceptance of the outsourcing contract by the supplier, the buyer and the supplier hold and exogenous debt level D_B and D_S, respectively. If the buyer's debt is safe, i.e. if $\underline{S} - \alpha D_S \geq D_B$, the equilibrium firm value of the buyer, $B^O_{e=1}$, is given by:*

$$B^O_{e=1} = \pi_1 \overline{S} + (1 - \pi_1)\,\underline{S} - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\right) - D_S \left[\pi_1 + (1 - \pi_1)\,\alpha\right] \text{ for } \underline{S} \geq D_S$$

$$B^O_{e=1} = \pi_1 \overline{S} + (1 - \pi_1)\,\underline{S} - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - (1 - \pi_1)\,\alpha \underline{S} \text{ for } \underline{S} < D_S$$

As for the supplier, the equilibrium firm value, $S^O_{e=1}$, is:

$$S^O_{e=1} = \frac{\pi_0}{\Delta\pi}\psi_S + D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right] \;\; for\; \underline{S} \geq D_S$$

$$S^O_{e=1} = \frac{\pi_0}{\Delta\pi}\psi_S + \pi_1 D_S + (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_S) \;\; for\; \underline{S} < D_S$$

The net gain to the buyer from the outsourcing regime is:

$$GainB^O_{e=1} = M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - D_S\left[\pi_1 + (1-\pi_1)\,\alpha\right] \;\; for\; \underline{S} \geq D_S \tag{14}$$

$$GainB^O_{e=1} = M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - (1-\pi_1)\,\alpha\underline{S} \;\; for\; \underline{S} < D_S \tag{15}$$

where the expressions for M are as previously stated. The supplier's optimal reaction with debt occurs if $\frac{\pi_0}{\Delta\pi}\psi_S \leq M - \psi_S$.

When the buyer's debt is safe, the expressions for the firm value of each player are influenced by two different effects: the limited liability effect and the supplier's debt effect. If we ignore the debt effect, i.e. if $D_S = 0$, one can verify that we end up with the same results of the model with zero cash holdings: the supplier's value, $\frac{\pi_0}{\Delta\pi}\psi_S$, derives entirely from the limited liability rent, and the buyer's value is just the expected value of production, $\pi_1\overline{S} + (1-\pi_1)\,\underline{S}$, minus the sum of supplier's cost of effort and supplier's limited liability rent, $\psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right)$.

Yet, given the assumption that the surplus from the outsourcing contract exceeds the supplier's limited liability rent ($\frac{\pi_0}{\Delta\pi}\psi_S \leq M - \psi_S$), the supplier can use debt as a strategic instrument to collect some of this surplus. In fact, as the supplier issues debt, its firm value is now augmented with one component equal to the expected payoff to the creditors ($D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right]$ for $\underline{S} \geq D_S$ and $\pi_1 D_S + (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_S)$ for $\underline{S} < D_S$), and the buyer's firm value is reduced by the same component, with the exception of the term associated with the supplier's bankruptcy costs $(1-\delta_S)$.[3] Therefore, from proposition 2, we conclude that the

[3]The buyer's firm value is not a function of these bankruptcy costs because they are fully incurred by the supplier's creditors.

supplier's debt has a positive effect on its total firm value and a negative effect on the buyer's. The supplier issues debt to receive a higher transfer payment in the the good state of nature, and consequently to claim more rents from the outsourcing contract, as debt increases the firm's bargaining power.

Note, however, that the supplier's potential to capture those rents depends on two important effects: the level of bankruptcy costs associated with the firm's debt (captured by δ_S) and the level of priority that its creditors have over the realized value of production in the bad state of nature $\underline{S}$ (as measured by α).[4] As to be expected, the supplier's firm value depends negatively on the level of bankruptcy costs associated with debt and positively on the level of priority that its creditors have over the realized value of production. Now, let us examine the changes to the equilibrium assuming that the buyer's debt is risky.

Proposition 3 *Assume that prior to the acceptance of the outsourcing contract by the supplier, the buyer and the supplier hold and exogenous debt level D_B and D_S, respectively. If the buyer's debt is risky, i.e. if $\underline{S} - \alpha D_S < D_B$, the equilibrium total firm value of the buyer, $B^O_{e=1}$, for $\underline{S} \geq D_S$ and $\underline{S} < D_S$ is, respectively:*

$$B^O_{e=1} = \pi_1 \overline{S} + (1-\pi_1)\,\underline{S}\,(1-\delta_B) - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_B)\right]$$

$$B^O_{e=1} = \pi_1 \overline{S} + (1-\pi_1)\,\underline{S}\,(1-\delta_B) - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_B)$$

As for the supplier, the equilibrium total firm value, $S^O_{e=1}$, is:

$$S^O_{e=1} = \frac{\pi_0}{\Delta\pi}\psi_S + D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right] \;\; \textit{for } \underline{S} \geq D_S$$

$$S^O_{e=1} = \frac{\pi_0}{\Delta\pi}\psi_S + \pi_1 D_S + (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_S) \;\; \textit{for } \underline{S} < D_S$$

[4] As noted earlier, α is the proportion of the realized value of production $\underline{S}$ that is captured by the supplier's creditors.

The net gain to the buyer from the outsourcing regime for $\underline{S} \geq D_S$ *and* $\underline{S} < D_S$ *is, respectively:*

$$GainB^{O}_{e=1} = M - (1-\pi_1)\,\underline{S}\delta_B - \psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right) - D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_B)\right] \quad (16)$$

$$GainB^{O}_{e=1} = M - (1-\pi_1)\,\underline{S}\delta_B - \psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_B) \quad (17)$$

where the expressions for M *are as previously stated. The supplier's optimal reaction with debt occurs if* $\frac{\pi_0}{\Delta\pi}\psi_S + (1-\pi_1)\,\underline{S}\delta_B \leq M - \psi_S$*. The buyer's gain from outsourcing depends negatively on the level of bankruptcy costs* δ_B*.*

The only difference between proposition 2 and proposition 3 comes from the fact that with the buyer's risky debt ($\underline{S} - \alpha D_S < D_B$), there is a value loss caused by the buyer's positive bankruptcy costs. These bankruptcy costs reduce the payoff to the buyer's creditors in the bad state of nature by $\delta_B\,(\underline{S} - \alpha D_S)$ for $\underline{S} \geq D_S$ and $\delta_B\,(1-\alpha)\,\underline{S}$ for $\underline{S} < D_S$. Therefore, the buyer's firm value with outsourcing is reduced, and as a consequence the buyer's gain from outsourcing is also reduced.

Since the supplier uses debt as an instrument to capture those gains, this suggests that whether the buyer's debt is safe or risky has an effect on the supplier's equilibrium reaction with debt. The new condition for the supplier's equilibrium reaction with debt stated in proposition 3, $\frac{\pi_0}{\Delta\pi}\psi_S + (1-\pi_1)\,\underline{S}\delta_B \leq M - \psi_S$, shows that when the buyer's debt is risky, the supplier can only issue positive debt if the surplus from the outsourcing contract, $M - \psi_S$, is enough not only to compensate the supplier's limited liability rent, $\frac{\pi_0}{\Delta\pi}\psi_S$, as in proposition 2, but also the buyer's bankruptcy costs associated with debt, $(1-\pi_1)\,\underline{S}\delta_B$. Hence, it is important to examine next the implications that the buyer's choice of safe versus risky debt can have on the derivation of the supplier's equilibrium capital structure.

Let us consider that at time $t = 0$ the supplier decides on the equilibrium debt level D^*_S and the buyer on whether to outsource with safe or risky debt. The

equilibrium is obtained by the intersection of each firms' reaction functions to the other's debt level. First, consider the buyer's reaction to the debt level set by the supplier. We have shown that the buyer's debt is safe when $\underline{S} - \alpha D_S \geq D_B$ and risky if otherwise. It follows that the buyer's best reaction to any level of $D_S \leq \frac{\underline{S}}{\alpha}$ that keeps his debt safe is given by:

$$D_B \leq \underline{S} - \alpha D_S \tag{18}$$

In addition to this reaction function, we need to ensure that the buyer's equity value remains positive for any level of debt. This extra condition is given by:[5]

$$D_B \leq \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S \tag{19}$$

Alternatively, the buyer's debt is always risky if $D_S > \frac{\underline{S}}{\alpha}$. For this additional case, once again, inequality (19) has to be satisfied. From (18), one can verify that for a given level of the buyer's and the supplier's debt, D_B and D_S, respectively, a lower (higher) realized value of production in the bad state of nature ($\underline{S}$) and a higher (lower) level of priority of the supplier's creditors over this value (as captured by α) increases the chances of the buyer's debt being risky (safe). This result is very intuitive: as the proportion of the realized value of production captured by the supplier's creditors increases (as α increases), less remains to be collected by the buyer's creditors, and consequently the higher is the probability of the buyer's debt being risky.

The supplier can set two debt levels that not only maximize the firm value but also ensure that the net gain to the buyer from outsourcing is zero, i.e. there are two debt levels that provide the supplier the whole surplus from the outsourcing contract. We denote these debt levels by $D_S\left(D_B^{SAFE}\right)$ and $D_S\left(D_B^{RISKY}\right)$. The level $D_S\left(D_B^{SAFE}\right)$ is the one that provides a zero gain to the buyer when he outsources

[5]See derivation of inequality (19) in the Appendix.

with safe debt, whereas the level $D_S\left(D_B^{RISKY}\right)$ ensures a zero gain, but now when he outsources with risky debt. These debt levels are obtained precisely by solving the net gain equations previously derived in propositions 2 and 3 for D_S such that the buyer breaks even. These are given by:

$$D_S\left(D_B^{SAFE}\right) = \frac{M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right)}{\pi_1 + (1-\pi_1)\,\alpha} \tag{20}$$

$$D_S\left(D_B^{RISKY}\right) = \frac{M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - (1-\pi_1)\,\underline{S}\delta_B}{\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_B)} \tag{21}$$

The supplier's best reaction to any debt level set by the buyer will depend on the relation between these two expressions. We show that:

$$\text{If } D_S \leq \frac{\underline{S}}{\alpha} \implies D_S\left(D_B^{SAFE}\right) \geq D_S\left(D_B^{RISKY}\right) \tag{22}$$

$$\text{If } D_S > \frac{\underline{S}}{\alpha} \implies D_S\left(D_B^{SAFE}\right) \leq D_S\left(D_B^{RISKY}\right) \tag{23}$$

It turns out that for $D_S \leq \frac{\underline{S}}{\alpha}$, the supplier's best reaction to any level of the buyer's debt is given by the functions $D_S = D_S\left(D_B^{SAFE}\right)$ if the buyer's safe debt condition (18) is not binding, i.e. for $0 \leq D_B < \underline{S} - \alpha D_S\left(D_B^{SAFE}\right)$; $D_S = \frac{\underline{S}-D_B}{\alpha}$ if the buyer's safe debt condition is binding, i.e. for $\underline{S}-\alpha D_S\left(D_B^{SAFE}\right) \leq D_B < \underline{S}-\alpha D_S\left(D_B^{RISKY}\right)$; and $D_S = D_S\left(D_B^{RISKY}\right)$ if the buyer's safe debt condition is not satisfied, i.e. for $D_B > \underline{S} - \alpha D_S\left(D_B^{RISKY}\right)$.

On the other hand, for $D_S > \frac{\underline{S}}{\alpha}$, where the buyer's debt is always risky, the supplier's best reaction is to set D_S equal to $D_S\left(D_B^{RISKY}\right)$ such that the buyer breaks even. All these reaction functions are once again constrained by inequality (19) of the buyer's positive equity value.

Using the intersection of the reactions functions above, the buyer's positive equity constraint (19), and the results of propositions 2 and 3, one can show that the equilibrium with endogenous debt is the one summarized in proposition 4.

Proposition 4 *Assume that prior to the acceptance of the outsourcing contract, the supplier decides on the amount of debt D_S to issue, and the buyer on whether to outsource with safe or risky debt.*

1) If $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$, *the buyer outsources with safe debt and the supplier sets the following equilibrium debt level:*

- $D_S^* = D_S\left(D_B^{SAFE}\right) = \frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha}$ *if both the buyer's safe debt condition (18) and positive equity condition (19) are not binding;*

- $D_S^* = \frac{\underline{S}-D_B}{\alpha}$ *if the buyer's safe debt condition (18) is binding; and*

- $D_S^* = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ *if the buyer's positive equity condition (19) is binding.*

2) Conversely, if $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} > \frac{\underline{S}}{\alpha}$, *the buyer outsources with risky debt and the supplier sets the following equilibrium debt level:*

- $D_S^* = D_S\left(D_B^{RISKY}\right) = \frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)-(1-\pi_1)\underline{S}\delta_B}{\pi_1+(1-\pi_1)\alpha(1-\delta_B)}$ *if the buyer's positive equity condition (19) is not binding; and*

- $D_S^* = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ *if the buyer's positive equity condition (19) is binding.*

Proposition 4 states the set of parameters for which the buyer outsources with safe or risky debt. Outsourcing with safe debt occurs when $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$, whereas outsourcing with risky debt occurs when the opposite is verified, i.e. when $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} > \frac{\underline{S}}{\alpha}$. The intuition behind these two inequalities is simple. First, let us assume the case where the creditors of the supplying firm have strict priority over the realized value of production in the bad state of nature, i.e. $\alpha = 1$. It follows

that, under this assumption, the set of parameters to have the buyer outsourcing with safe and risky debt simplifies to (24) and (25), respectively.

$$M - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\right) \leq \underline{S} \tag{24}$$

$$M - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\right) > \underline{S} \tag{25}$$

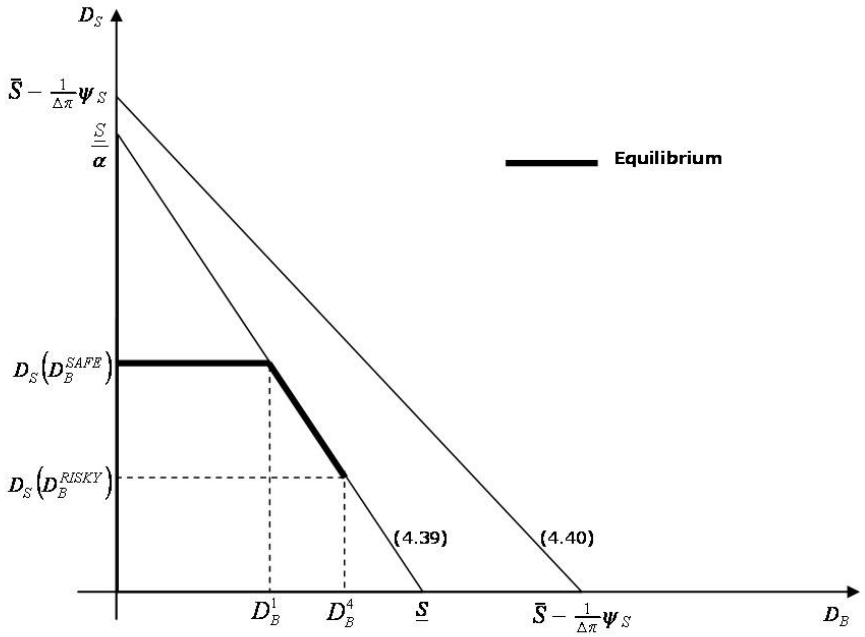
The results show that the buyer outsources with safe (risky) debt if the surplus of the outsourcing contract, net of the supplier's limited liability rent ($M - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\psi_S\right)$) is lower (higher) than the realized value of production in the bad state of nature ($\underline{S}$). Since this surplus ($M - \psi_S$) is either given by $\psi_B - \psi_S$ or $\Delta\pi\Delta S - \psi_S$, this suggests that outsourcing with risky debt is more likely to occur when there are higher effort cost differences between internal production and outsourcing (higher $\psi_B - \psi_S$) and greater benefit from exerting effort, in particular greater wedge in the probabilities associated with each state of nature and higher volatility in the values of production (higher $\Delta\pi\Delta S$).

Second, let us assume that the creditors of the supplying firm do not have strict priority over $\underline{S}$, i.e. $0 \leq \alpha < 1$. From proposition 4, one can verify that as the proportion of the realized value of production $\underline{S}$ collected by the buyer's creditors is increased, i.e.. as α decreases, there is naturally more scope to have the buyer outsourcing with safe debt.

We use Figures 4.1, 4.2 and 4.3 to illustrate the results of the equilibrium with endogenous debt. Figure 4.1 and 4.2 depict the equilibrium when the buyer outsources with safe debt and $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$, whereas Figure 4.3 considers the case where he outsources with risky debt and $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} > \frac{\underline{S}}{\alpha}$. Let us first analyze Figure 4.1 where the condition for the buyer's positive equity (19) is not binding. The supplier sets D_S^* equal to $D_S\left(D_B^{SAFE}\right)$ for any level of the buyer's debt between zero and D_B^1. For this range the buyer breaks even and the supplier's firm value

Figure 4.1: Equilibrium with Safe Debt and Positive Equity Condition not Binding

Level of debt issued by the supplier, D_S, as a function of the level of debt issued by the buyer, D_B. Constraint (18), given by $D_B \leq \underline{S} - \alpha D_S$, is the buyer's safe debt condition, and constraint (19), given by $D_B \leq \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S$, is the buyer's positive equity condition. *In this example, the buyer's positive equity condition is not binding the equilibrium and the buyer's debt is always safe.* $D_S\left(D_B^{SAFE}\right)$ and $D_S\left(D_B^{RISKY}\right)$ are the supplier's debt levels that ensure the buyer to break even when the buyer's debt is safe and risky, respectively. There is a multiple equilibrium where the supplier adopts the debt level $D_S\left(D_B^{SAFE}\right)$ if the buyer's safe debt condition is not binding $\left(D_B < \underline{S} - \alpha D_S\left(D_B^{SAFE}\right) \equiv D_B^1\right)$ and $D_S = \frac{\underline{S} - D_B}{\alpha}$ if the buyer's safe debt condition is binding $\left(D_B^1 \leq D_B < \underline{S} - \alpha D_S\left(D_B^{RISKY}\right) \equiv D_B^4\right)$.



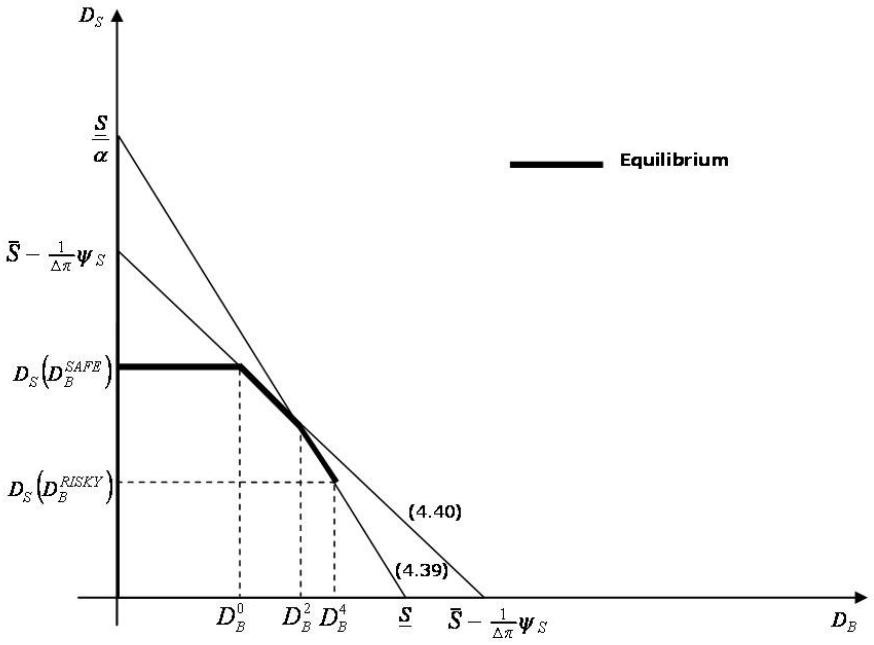
becomes:

$$S_{e=1}^{O} = \frac{\pi_0}{\Delta\pi}\psi_S + \frac{M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right)}{\pi_1 + (1 - \pi_1)\,\alpha}\left[\pi_1 + (1 - \pi_1)\,\alpha\,(1 - \delta_S)\right] \tag{26}$$

From this expression it is clear that if the supplier's bankruptcy costs are zero ($\delta_S = 0$), the supplier's firm value simplifies to the outsourcing surplus: $M - \psi_S$. The supplier reaps all the gains from the outsourcing contract and still ensures the buyer's participation. As we discussed earlier, this value is reduced if there are positive bankruptcy costs ($0 < \delta_S \leq 1$) or if supplier's creditors do not have strict priority over the realized value of production $\underline{S}$ in the bad state of nature ($0 < \alpha < 1$). Furthermore, for any level of the buyer's debt between D_B^1 and D_B^4, the buyer's safe debt condition is binding and the suppliers sets the equilibrium debt as

Figure 4.2: Equilibrium with Safe Debt and Positive Equity Condition Binding

Level of debt issued by the supplier, D_S, as a function of the level of debt issued by the buyer, D_B. Constraint (18), given by $D_B \leq \underline{S} - \alpha D_S$, is the buyer's safe debt condition, and constraint (19), given by $D_B \leq \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S$, is the buyer's positive equity condition. *In this example, the buyer's positive equity condition is binding the equilibrium for $D_B^0 \leq D_B \leq D_B^2$ and the buyer's debt is always safe.* $D_S\left(D_B^{SAFE}\right)$ and $D_S\left(D_B^{RISKY}\right)$ are the supplier's debt levels that ensure the buyer to break even when the buyer's debt is safe and risky, respectively. There is a multiple equilibrium where the supplier adopts the debt level $D_S\left(D_B^{SAFE}\right)$ if the buyer's positive equity condition is not binding ($D_B < \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S\left(D_B^{SAFE}\right) \equiv D_B^0$), $D_S = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ if the buyer's positive equity condition is binding ($D_B^0 \leq D_B \leq \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S \equiv D_B^2$) and $D_S = \frac{\underline{S} - D_B}{\alpha}$ if the buyer's safe debt condition is binding ($D_B^2 < D_B < \underline{S} - \alpha D_S\left(D_B^{RISKY}\right) \equiv D_B^4$).

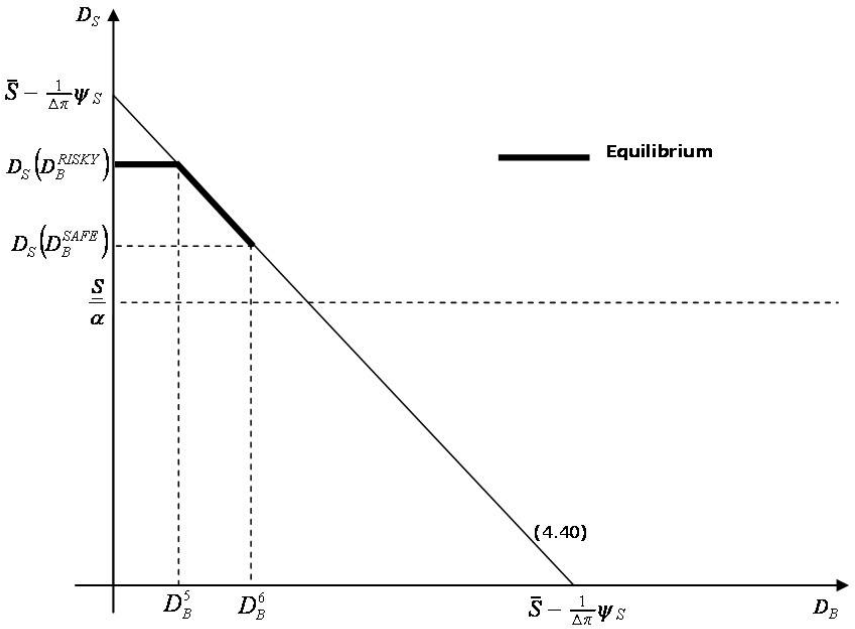


$D_S^* = \frac{\underline{S} - D_B}{\alpha}$, sharing the surplus of the outsourcing contract with the buyer. The proportion of the surplus collected by the supplier (buyer) decreases (increase) as the buyer's debt increases from D_B^1 to D_B^4. Although all these debt combinations are part of the equilibrium, only one of them configures a situation where the total value generated with outsourcing by both firms is maximized. We show that from a global optimization point of view, as soon as there are positive bankruptcy costs, the equilibrium $\left(D_B^4, D_S^* = \frac{\underline{S} - D_B^4}{\alpha}\right)$ is preferable as this is the one that minimizes the supplier's debt level, and consequently the value loss caused by bankruptcy costs.

Figure 4.2 provides an example where the condition for the buyer's positive equity (19) is binding for some part of the equilibrium. The difference now is that for the

Figure 4.3: Equilibrium with Risky Debt

Level of debt issued by the supplier, D_S, as a function of the level of debt issued by the buyer, D_B. $D_S\left(D_B^{SAFE}\right)$ and $D_S\left(D_B^{RISKY}\right)$ are the supplier's debt levels that ensure the buyer to break even when the buyer's debt is safe and risky, respectively. *In this example the buyer's debt is always risky.* Constraint (19), given by $D_B \leq \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S$, is the buyer's positive equity condition. There is a multiple equilibrium where the supplier adopts the debt level $D_S\left(D_B^{RISKY}\right)$ if the buyer's positive equity condition is not binding ($D_B < \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S\left(D_B^{RISKY}\right) \equiv D_B^5$) and $D_S = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ if the buyer's positive equity condition is binding ($D_B^5 \leq D_B < \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_S\left(D_B^{SAFE}\right) \equiv D_B^6$).



range $D_B^0 < D_B \leq D_B^2$ the equilibrium is given by $D_S^* = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ instead of $D_S\left(D_B^{SAFE}\right)$ or $D_S^* = \frac{\underline{S} - D_B}{\alpha}$ as in Figure 4.1. For the same reason as before, equilibrium $\left(D_B^4, D_S^* = \frac{\underline{S} - D_B^4}{\alpha}\right)$ is preferable from a global optimization perspective.

Finally, in Figure 4.3, when $\frac{M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right)}{\pi_1 + (1-\pi_1)\alpha} > \frac{\underline{S}}{\alpha}$ and the buyer's debt is always risky, the supplier sets D_S^* equal to $D_S\left(D_B^{RISKY}\right)$ when condition (19) is not binding, i.e. for $D_B \leq D_B^5$. For this level the buyer's net gain from outsourcing is zero and the supplier's firm value is:

$$S_{e=1}^O = \frac{\pi_0}{\Delta\pi}\psi_S + \frac{M - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - (1-\pi_1)\,\underline{S}\delta_B}{\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_B)}\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right] \quad (27)$$

Only when there are no bankruptcy costs (δ_B and δ_S are zero), the supplier is able to collect the maximum surplus from outsourcing: $M - \psi_S$. On the other

hand, when the buyer's positive equity condition is binding, the supplier sets $D_S^* = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B$ for the range $D_B^5 < D_B \leq D_B^6$. Once again, from a global optimization point of view, the equilibrium with the supplier's lowest debt level $\left(D_B^6, D_S^* = \left(\overline{S} - \frac{1}{\Delta\pi}\psi_S\right) - D_B^6\right)$ is preferable as it minimizes the value loss caused by bankruptcy costs.

3 Conclusions

This paper examines the effect of capital structure on the production decision of firms in a principal-agent framework.

As the advantage from the outsourcing regime increases, such that the surplus from outsourcing is enough to cover the supplier's limited liability rent, the supplier can switch from accumulating cash to issuing debt. We find that the supplier has an incentive to use as much debt as possible because the proportion of the outsourcing surplus the firm collects depends positively on debt. Our model shows, however, that the supplier's potential to collect this surplus depends negatively on its level of bankruptcy costs and positively on the level of priority that the firm's creditors have over the value of production at liquidation.

Next, we investigate the effect of the buyer's choice of safe versus risky debt on the supplier's capital structure, as with risky debt we have the additional effect of bankruptcy costs. Our results show that when the buyer's debt is risky, a greater surplus from outsourcing is required to have an equilibrium where the supplier issues debt since bankruptcy costs reduces the buyer's total firm value under outsourcing and the incentives to outsource.

Finally, we derive the buyer's equilibrium capital structure, and find that the buyer's decision to outsource with safe versus risky debt depends on the surplus

from outsourcing and how it compares with the realized value of production in the bad state of nature. Greater advantage from the outsourcing contract allows an equilibrium where the buyer outsources with risky debt.

Our model provides new predictions that can be empirically testable. We find that the supplier switches from accumulating cash to issuing debt as the surplus from outsourcing increases, i.e. as the cost differential between the buyer and the supplier increases, or as the benefit associated with the supplier's effort increases. As discussed earlier, this latter benefit is linked with greater probabilities of reaching high values of production in good states of nature and with high volatilities in the values of production. Moreover, the buyer's debt level also depends positively on this surplus. Therefore, our model predicts that in more volatile industries (for example, in industries more affected by economic shocks) and in industries where the level of efficiency of suppliers is greater, firms involved in outsourcing (both buyers and suppliers) may show high leverage. Rather, in stable industries or with low level of efficiency of suppliers, firms tend to participate in the outsourcing relationship with safer capital structures, or even accumulating high levels of cash.

4 Appendix

Proof of proposition 1

The transfer payments with exogenous debt are derived analogously as in the proof of proposition **??** when both the incentive and limited liability constraint are binding, i.e. by solving the incentive constraint (8) and the limited liability constraint (11) with equalities. These payments $\overline{t}^* = \frac{1}{\Delta\pi}\psi_S + D_S$ and $\underline{t}^* = 0$ ensure that condition (10) is satisfied since $\overline{t}^* = \frac{1}{\Delta\pi}\psi_S + D_S > 0$ and that (9) is also satisfied since $SEquity^O_{e=1} = \pi_1 \max\left[\overline{t} - D_S, 0\right] + (1-\pi_1)\max\left[\underline{t} - D_S, 0\right] - \psi_S = \frac{\pi_0}{\Delta\pi}\psi_S \geq 0$.

Proof of proposition 2

Analogously to the proof of proposition **??**, we obtain the equilibrium values by substituting the transfer payments derived in proposition 1 into the appropriate value functions, assuming the condition for the buyer's safe debt $\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha \geq D_B$. The buyer's total firm value is $B^O_{e=1} = BDebt^O_{e=1} + BEquity^O_{e=1}$, where the equilibrium value of debt, $BDebt^O_{e=1}$, is D_B and the equilibrium value of equity, $BEquity^O_{e=1}$, is:

$$BEquity^O_{e=1} = \pi_1\overline{S} + (1-\pi_1)\,\underline{S} - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - D_S\left[\pi_1 + (1-\pi_1)\,\alpha\right] - D_B \text{ for } \underline{S} \geq D_S$$

$$BEquity^O_{e=1} = \pi_1\overline{S} + (1-\pi_1)\,\underline{S} - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - (1-\pi_1)\,\alpha\underline{S} - D_B \text{ for } \underline{S} < D_S$$

As for the supplier, the total firm value is $S^O_{e=1} = SDebt^O_{e=1} + SEquity^O_{e=1}$, where the equilibrium equity value, $SEquity^O_{e=1}$, equals the limited liability rent debt $\frac{\pi_0}{\Delta\pi}\psi_S$, and the equilibrium debt value, $SDebt^O_{e=1}$, is:

$$SDebt^O_{e=1} = D_S\left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right] \text{ for } \underline{S} \geq D_S$$

$$SDebt^O_{e=1} = \pi_1 D_S + (1-\pi_1)\,\alpha\underline{S}\,(1-\delta_S) \text{ for } \underline{S} < D_S$$

The condition for the supplier's optimal reaction with debt $\frac{\pi_0}{\Delta\pi}\psi_S \leq M - \psi_S$ is derived with an analogous procedure to the one used in proposition **??**. First, we determine the level of debt that ensures to the buyer a net gain of zero. We solve the net gain expression stated in proposition 2 for D_S and we obtain that D_S equals $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha}$. An equilibrium reaction with positive debt implies then condition $D_S \geq 0$ to hold, i.e. $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \geq 0$. After simplifying, this inequality becomes: $\frac{\pi_0}{\Delta\pi}\psi_S \leq M - \psi_S$.

Proof of proposition 3

This proposition is derived with the same steps as proposition 2, assuming now the condition for the buyer's risky debt $\underline{S} - \underline{t} - \max(D_S - \underline{t}, 0)\alpha < D_B$. The buyer's firm value is $B^O_{e=1} = BDebt^O_{e=1} + BEquity^O_{e=1}$, where the equilibrium value of debt, $BDebt^O_{e=1}$, is:

$$BDebt^O_{e=1} = \pi_1 D_B + (1-\pi_1)\left(\underline{S} - \alpha D_S\right)(1-\delta_B) \text{ for } \underline{S} \geq D_S$$

$$BDebt^O_{e=1} = \pi_1 D_B + (1-\pi_1)(1-\alpha)\,\underline{S}\,(1-\delta_B) \text{ for } \underline{S} < D_S$$

and the equilibrium value of equity, $BEquity^O_{e=1}$, is:

$$BEquity^O_{e=1} = \pi_1 \overline{S} - \psi_S\left(1 + \frac{\pi_0}{\Delta\pi}\right) - \pi_1 D_S - \pi_1 D_B$$

On the other hand, the supplier's firm value is $S^O_{e=1} = SDebt^O_{e=1} + SEquity^O_{e=1}$, where the expressions for the equilibrium equity value, $SEquity^O_{e=1}$, and debt value, $SDebt^O_{e=1}$, are the same as the ones stated in the previous proof.

The condition for the supplier's optimal reaction with debt $\frac{\pi_0}{\Delta\pi}\psi_S + (1-\pi_1)\,\underline{S}\delta_B \leq M - \psi_S$ is obtained with the same intuition as in proposition 2. Solving the buyer's net gain for D_S gives that D_S equals $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)-(1-\pi_1)\underline{S}\delta_B}{\pi_1+(1-\pi_1)\alpha(1-\delta_B)}$. In order for this amount of debt to be positive the following condition has to be satisfied: $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)-(1-\pi_1)\underline{S}\delta_B}{\pi_1+(1-\pi_1)\alpha(1-\delta_B)} \geq 0$. This simplifies to: $\frac{\pi_0}{\Delta\pi}\psi_S + (1-\pi_1)\,\underline{S}\delta_B \leq M - \psi_S$.

Finally, we show that the buyer's gain from outsourcing depends negatively on bankruptcy costs as:

$\frac{\partial GainB^{O}_{e=1}}{\partial \delta_B} = -(1-\pi_1)(\underline{S} - \alpha D_S) < 0$ for $\underline{S} \geq D_S$ and

$\frac{\partial GainB^{O}_{e=1}}{\partial \delta_B} = -(1-\pi_1)\underline{S}(1-\alpha) < 0$ for $\underline{S} < D_S$.

Derivation of condition (19) for the buyer's positive equity value

The buyer's equity value with risky debt is stated in the proof of proposition 3 as $BEquity^{O}_{e=1} = \pi_1 \overline{S} - \left(\psi_S + \frac{\pi_0}{\Delta\pi}\psi_S\right) - \pi_1 D_S - \pi_1 D_B$. Condition (19) is obtained by solving $BEquity^{O}_{e=1} \geq 0$ for D_B.

Proof of conditions (22) and (23)

We show that the inequality $D_S\left(D_B^{SAFE}\right) \geq D_S\left(D_B^{RISKY}\right)$ given by $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \geq \frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)-(1-\pi_1)\underline{S}\delta_B}{\pi_1+(1-\pi_1)\alpha(1-\delta_B)}$ simplifies to $D_S\left(D_B^{SAFE}\right) = \frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$. Therefore, for $D_S \leq \frac{\underline{S}}{\alpha}$ condition (22) is verified. From this, it follows immediately that for the opposite case $D_S > \frac{\underline{S}}{\alpha}$, condition (23) is also verified.

Proof of proposition 4

We derive the results of proposition 4 by simply using the intersection of the firm's reactions functions and the buyer's positive equity constraint (19). The equilibrium condition to have the buyer outsourcing with safe debt, $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$, is obtained as follows. We have shown previously that when the buyer's debt is safe, condition $D_S\left(D_B^{SAFE}\right) \geq D_S\left(D_B^{RISKY}\right)$ is verified, and this simplifies to $D_S\left(D_B^{SAFE}\right) = \frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$. Thus, the buyer outsources with safe debt when $\frac{M-\psi_S\left(1+\frac{\pi_0}{\Delta\pi}\right)}{\pi_1+(1-\pi_1)\alpha} \leq \frac{\underline{S}}{\alpha}$. When the opposite holds the buyer outsources with risky debt.

Proof that the equilibrium with the lowest D_S^* is preferred by a global optimizer

We show that as soon as the supplier's bankruptcy costs are positive ($0 < \delta_S \leq 1$), the value under global maximization depends negatively on the supplier's debt, and consequently the equilibrium that incorporates the lowest D_S^* is preferred. Let us consider the case where the buyer's debt is safe as an example. We know from proposition 2 that the buyer's and the supplier's firm value are, respectively:

$$B_{e=1}^O = \pi_1 \overline{S} + (1-\pi_1)\,\underline{S} - \psi_S \left(1 + \frac{\pi_0}{\Delta\pi}\right) - D_S^* \left[\pi_1 + (1-\pi_1)\,\alpha\right] \tag{28}$$

$$S_{e=1}^O = \frac{\pi_0}{\Delta\pi}\psi_S + D_S^* \left[\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S)\right] \tag{29}$$

The value under global maximization, $GM_{e=1}^O = B_{e=1}^O + S_{e=1}^O$, simplifies to:

$$GM_{e=1}^O = \pi_1 \overline{S} + (1-\pi_1)\,\underline{S} - \psi_S - D_S^* \left[(\pi_1 + (1-\pi_1)\,\alpha) - (\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S))\right] \tag{30}$$

and $\frac{\partial GM_{e=1}^O}{\partial D_S^*}$ to:

$$\frac{\partial GM_{e=1}^O}{\partial D_S^*} = -\left[(\pi_1 + (1-\pi_1)\,\alpha) - (\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S))\right] \tag{31}$$

As $(\pi_1 + (1-\pi_1)\,\alpha) \geq (\pi_1 + (1-\pi_1)\,\alpha\,(1-\delta_S))$, if follows that $\frac{\partial GM_{e=1}^O}{\partial D_S^*} \leq 0$.

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